Formula Application

a) πR

b) $2\pi R$

c) $\frac{4}{3}\pi R$

d) πR^2

e) $2\pi R^2$

f) $4\pi R^2$

g) $R\theta$

h) πR^3

i) $2\pi R^3$

j) $\frac{4}{3}\pi R^3$

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Formula	Application
$a)\ \pi R$	None at all
$b)\ 2\pi R$	Circumference of circle (radius R)
$c)\ {}^{4}\!/_{3}\,\pi R$	Nada
$d)\ \pi R^2$	Area of a circle (radius R)
$e)\ 2\pi R^2$	Bupkis!
$f)\ 4\pi R^2$	Surface area of a sphere (radius R)
$g)\ R\theta$	Arc length of a segment of a circle
$h)\ \pi R^3$	Useless
$i)\ 2\pi R^3$	Also useless
$j)\ {}^{4}\!/_{3}\,\pi R^3$	Volume of a sphere (radius R)

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Formula	Application
$a)\ \pi R$	
$b)\ 2\pi R$	
$c)\ \frac{opposite}{hypotenuse}$	
$d)\ \pi R^2$	
$e)\ 2\pi R^2$	
$f)\ 4\pi R^2$	
$g)\ R\theta$	
$h)\ \frac{opposite}{adjacent}$	
$i)\ \sin(30^\circ)$	
$j)\ \frac{4}{3}\pi R^3$	

Formula	Application
$a)\ \pi R$	None at all
$b)\ 2\pi R$	Circumference of circle (radius R)
$c)\ \frac{opposite}{hypotenuse}$	**SOH**-CAH-TOA
$d)\ \pi R^2$	Area of a circle (radius R)
$e)\ 2\pi R^2$	Bupkis!
$f)\ 4\pi R^2$	Surface area of a sphere (radius R)
$g)\ R\theta$	Arc length of a segment of a circle
$h)\ \frac{opposite}{adjacent}$	SOH-CAH-**TOA**
$i)\ \sin(30^\circ)$	1/2
$j)\ \frac{4}{3}\pi R^3$	Volume of a sphere (radius R)

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Vectors to Nashville!

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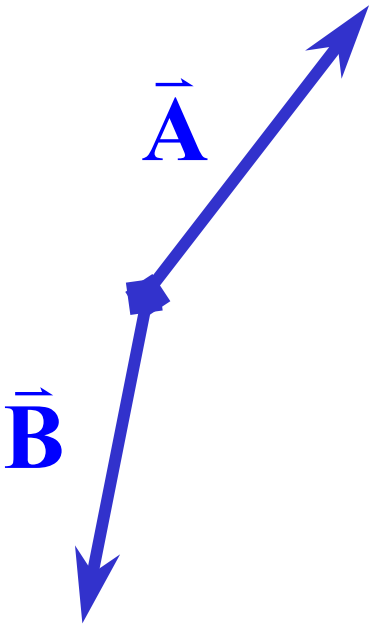
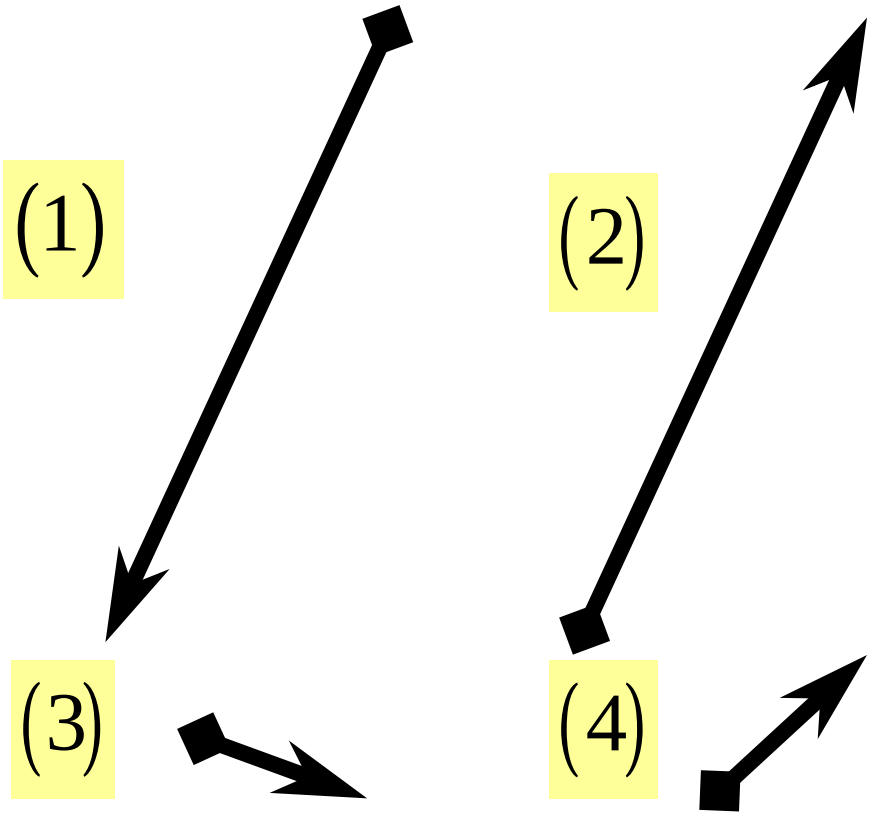
Geometric Vector Addition and Subtraction



$$\vec{\mathbf{A}} + \vec{\mathbf{B}} = ?$$

$$\vec{\mathbf{A}} - \vec{\mathbf{B}} = ?$$

$$\vec{\mathbf{B}} - \vec{\mathbf{A}} = ?$$



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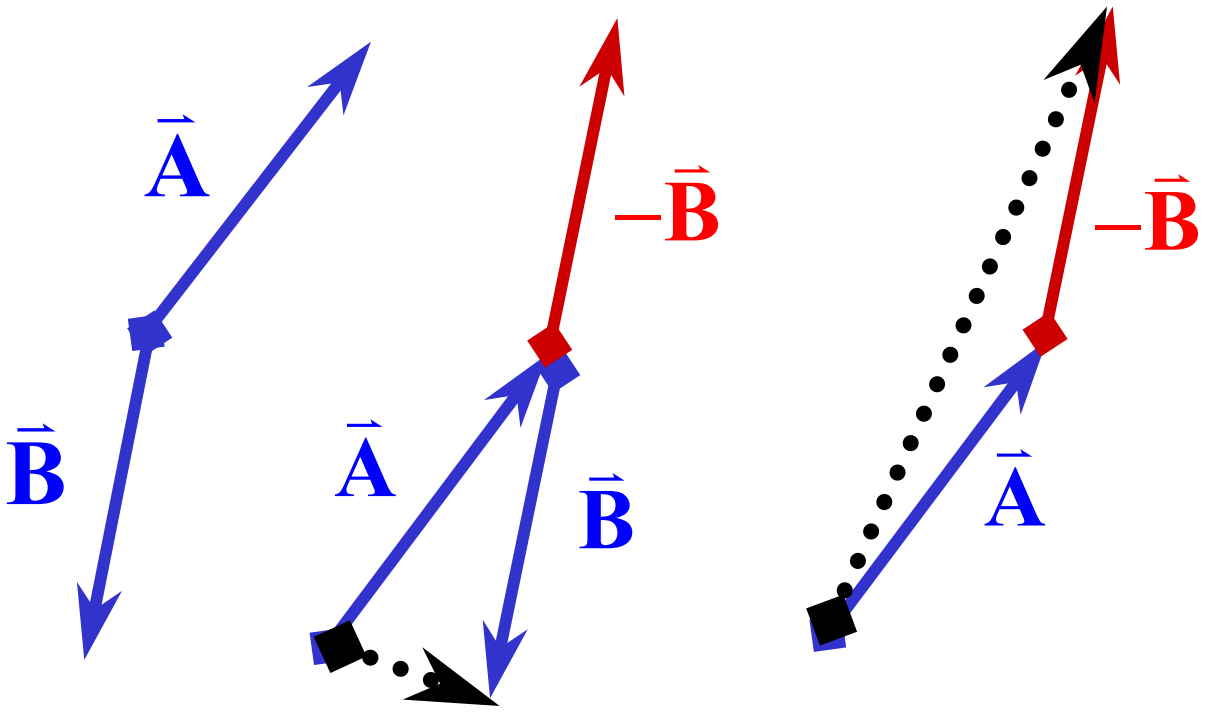
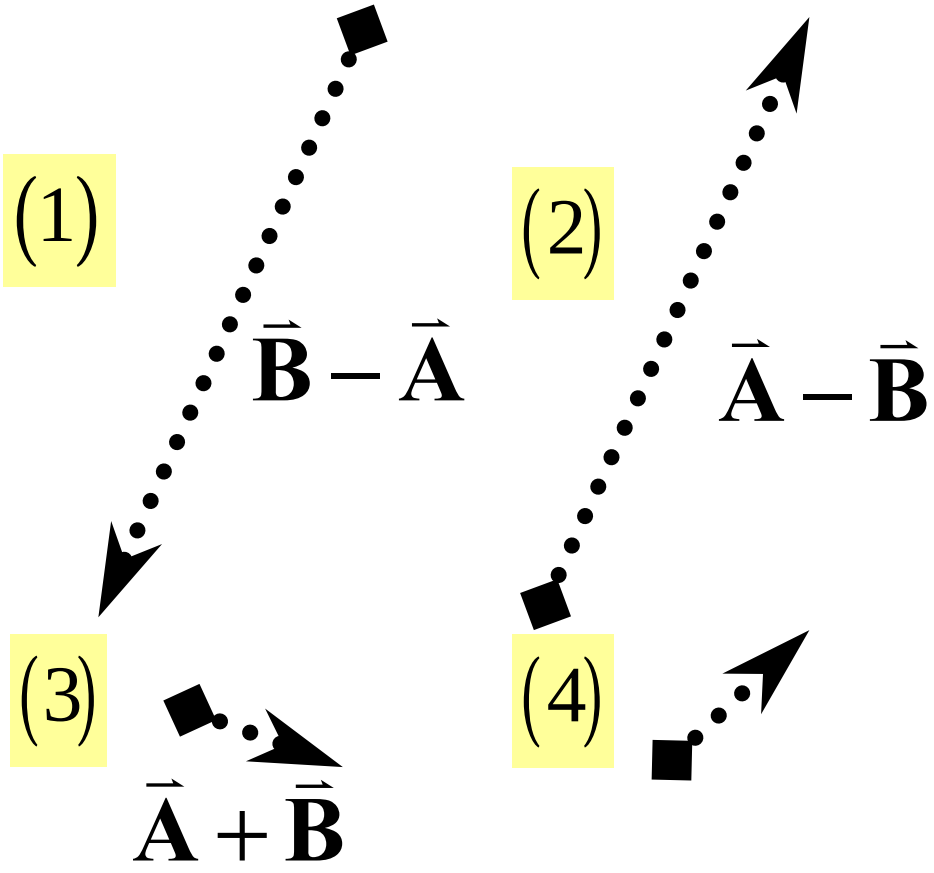

$\vec{A}$
$\vec{B}$
$-\vec{B}$
$\vec{A}$
$\vec{B}$
$-\vec{B}$
$\vec{A}$


(1)
$\vec{B}-\vec{A}$
(2)
$\vec{A}-\vec{B}$
(3)
$\vec{A}+\vec{B}$
(4)

Straight Line Motion

Displacement / Speed / Velocity

Position $\mathbf{x}$ Coordinate of object at time t.

Displacement $\Delta\mathbf{x}$ Difference in coordinate between time t and later time $\mathbf{t}+\Delta\mathbf{t}$

Average Speed $S_{AV} = \dfrac{\Delta\mathbf{L}}{\Delta\mathbf{t}}$ Total path (delta-L) traveled in delta-t divided by delta-t

Instantaneous Speed $S_{INST} = \left|\vec{\mathbf{v}}\right|$ Instantaneous speed is Magnitude of instantaneous velocity

Average Velocity $\mathbf{v}_{AV} = \dfrac{\Delta\mathbf{x}}{\Delta\mathbf{t}}$ Total displacement (delta-x) in delta-t divided by delta-t

Instantaneous Speed $\mathbf{v} = \dfrac{d\mathbf{x}}{d\mathbf{t}}$ Instantaneous velocity (or just "velocity") is displacement dx in infinitesimal time dt divided by dt.

$$\mathbf{v} = \lim_{\Delta t \to 0} \frac{\Delta\mathbf{x}}{\Delta\mathbf{t}} = \lim_{\Delta t \to 0} \mathbf{v}_{AV}$$

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Work

Displacement $\vec{\mathbf{s}}$ *or* $\Delta\vec{\mathbf{r}}$ — Difference in vector position between time t and later time $\mathbf{t}+\Delta\mathbf{t}$

1D-Displacement $\mathbf{s}$ *or* Δx — Difference in position along a single axis between time t and later time $\mathbf{t}+\Delta\mathbf{t}$

Force $\vec{\mathbf{F}}$ *or* $\mathbf{F}$ — Net force (vector) or the component of Force along same direction as the displacement

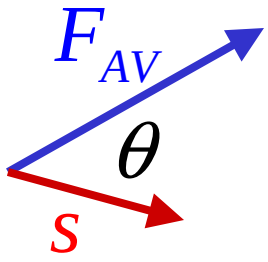
Work (1-D) $W = Fs = F(\Delta x)$ — Work in 1-Dimension

Work (Varying Force) $W = F_{AV}s = \int_{x_1}^{x_2} F\,dx$ — Work in 1-D for Position-varying force (e.g. spring)

Work (Average force, 3-D motion)

$$W = \vec{F}_{AV} \bullet \vec{s}$$

$$W = F_{AV}\, s \cos(\theta)$$



Work (Arbitrary force and direction) $W = \int_{P_1}^{P_2} \vec{F} \bullet d\vec{\ell}$ — General definition, all else is special case.

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Power

General Definition

$$P_{Inst} = \frac{dW}{dt}$$

Instantaneous rate of Work done.

Average Power

$$P_{AV} = \frac{\Delta W}{\Delta t}$$

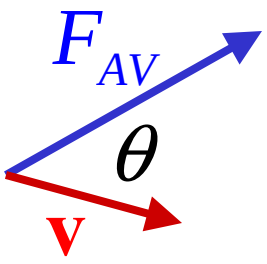
Average rate of Work done.

Average Power (1-D)

$$P_{AV} = F_{AV}\ \mathbf{v}$$

Average Power (3-D)

$$P_{AV} = \vec{F}_{AV} \bullet \vec{\mathbf{v}}$$



$$P_{AV} = \vec{F}_{AV} \bullet \vec{\mathbf{v}}$$

$$P_{AV} = F_{AV}\,\mathbf{v}\cos(\theta)$$

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Straight Line Motion

Displacement / Velocity / Acceleration

Position $\mathbf{x}$ m

Velocity $\mathbf{v} = \dfrac{\mathbf{dx}}{\mathbf{dt}}$ m/s

Acceleration $\mathbf{a} = \dfrac{\mathbf{dv}}{\mathbf{dt}}$ m/s^2

$$\mathbf{a} = \frac{\mathbf{d^2x}}{\mathbf{dt^2}}$$

Constant Acceleration Formulae

$$\mathbf{x} = \mathbf{x_0} + \mathbf{v_0 t} + \frac{\mathbf{1}}{\mathbf{2}}\mathbf{a_0 t^2}$$

$$\mathbf{v} = \mathbf{v_0} + \mathbf{a_0 t}$$

$$\mathbf{a} = \mathbf{a_0}$$

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Straight Line Motion and Rotation Analogues

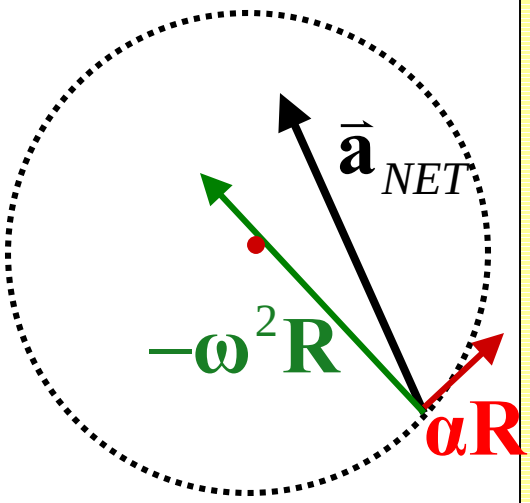
Angle (Position) θ *radians* $(x\ m)$

Angular Vel. (Velocity) $\omega = \frac{d\theta}{dt}\ rad/s$ $\left(v = \frac{dx}{dt}\ m/s \right)$

Angular Accel. $\alpha = \frac{d\omega}{dt}\ rad/s^2$ $\left(a = \frac{dv}{dt}\ m/s^2 \right)$

(Acceleration) $\alpha = \frac{d^2\theta}{dt^2}$

Constant Angular Acceleration Formulae



$$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha_0 t^2$$

$$\omega = \omega_0 + \alpha_0 t$$

$$v_{CIRCUMF} = \omega R$$

$$a_{CIRCUMF} = \alpha R$$

$$a_{RADIAL} = -\omega^2 R$$

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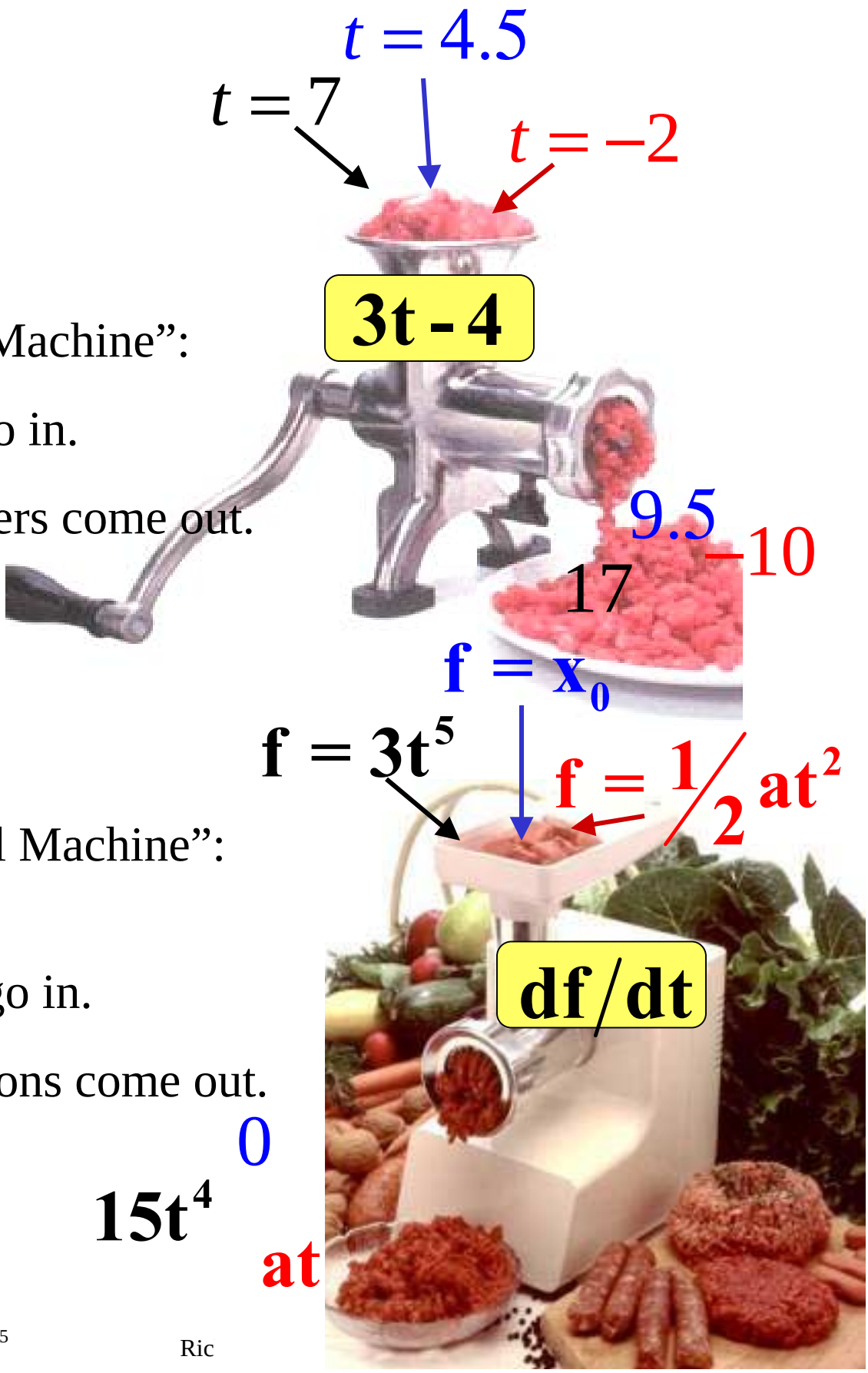
Meat-Grinder Math



Basic

"Function Machine":

Numbers go in.

New numbers come out.

Deluxe

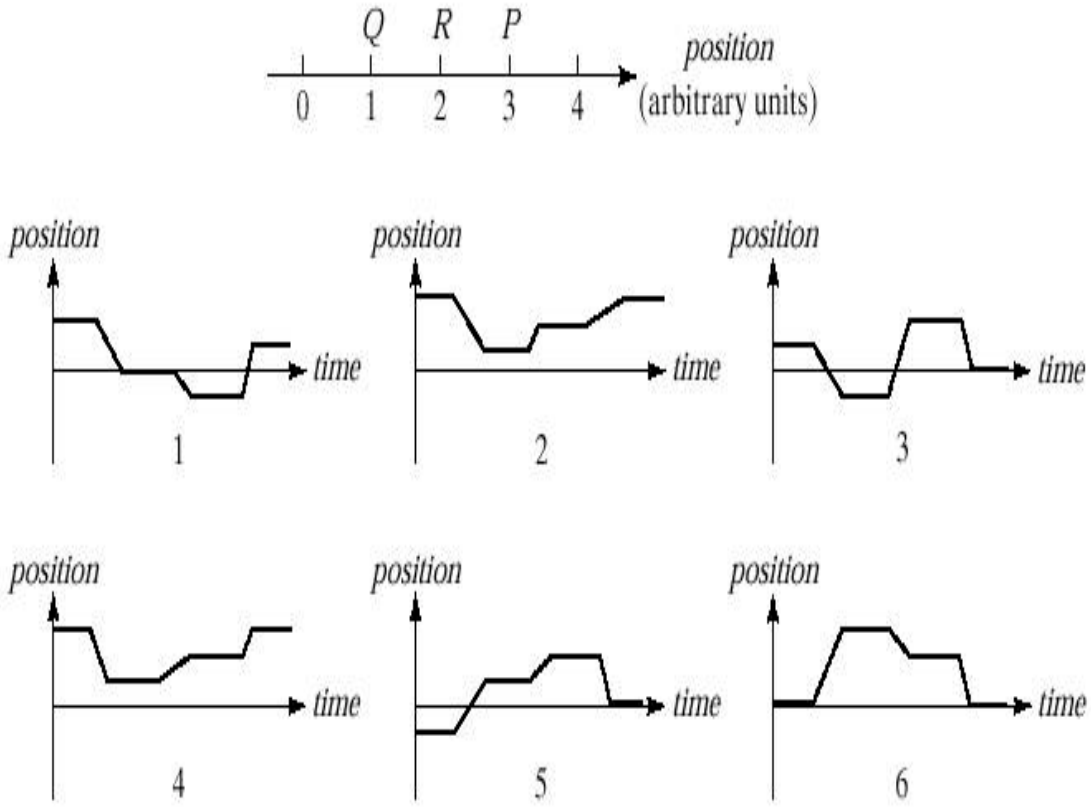
"Functional Machine":

Functions go in.

New functions come out.

Ric

A person initially at point *P* in the illustration stays there a moment and then moves along the axis to *Q* and stays there a moment. She then runs quickly to R, stays there a moment, and then strolls slowly back to P. Which of the position vs. time graphs below correctly represents this motion?



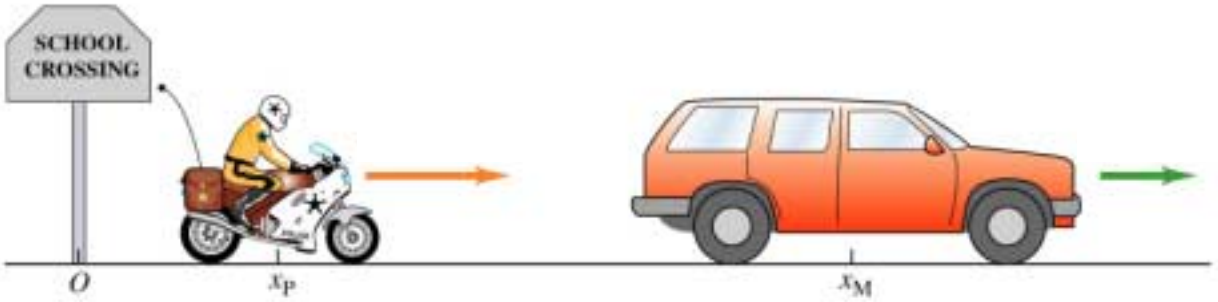
If you drop an object in the absence of air resistance, it accelerates downward at $9.8\ m/s^2$. If instead you throw it downward, its downward acceleration after release is

1. less than $9.8\ m/s^2$
2. $9.8\ m/s^2$
3. More than $9.8\ m/s^2$

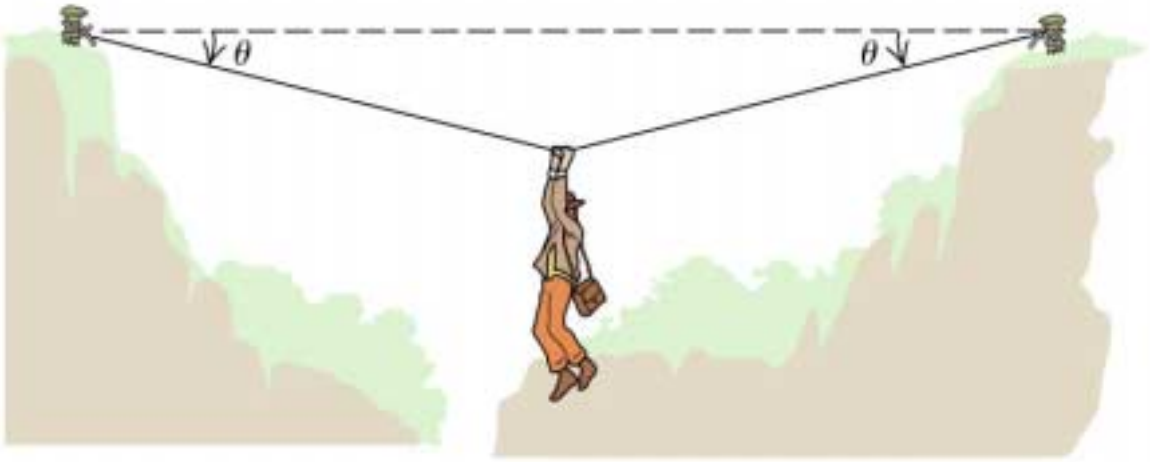
If you drop an object in the absence of air resistance, it accelerates downward at $9.8\,m/s^2$ .If instead you throw it downward,its downward acceleration after release is

1. less than $9.8\,m/s^2$
2. $9.8\,m/s^2$
3. More than $9.8\,m/s^2$

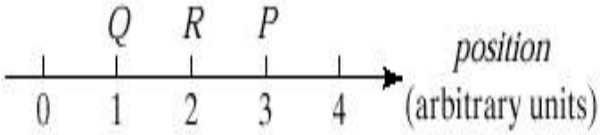
Problem 2.68

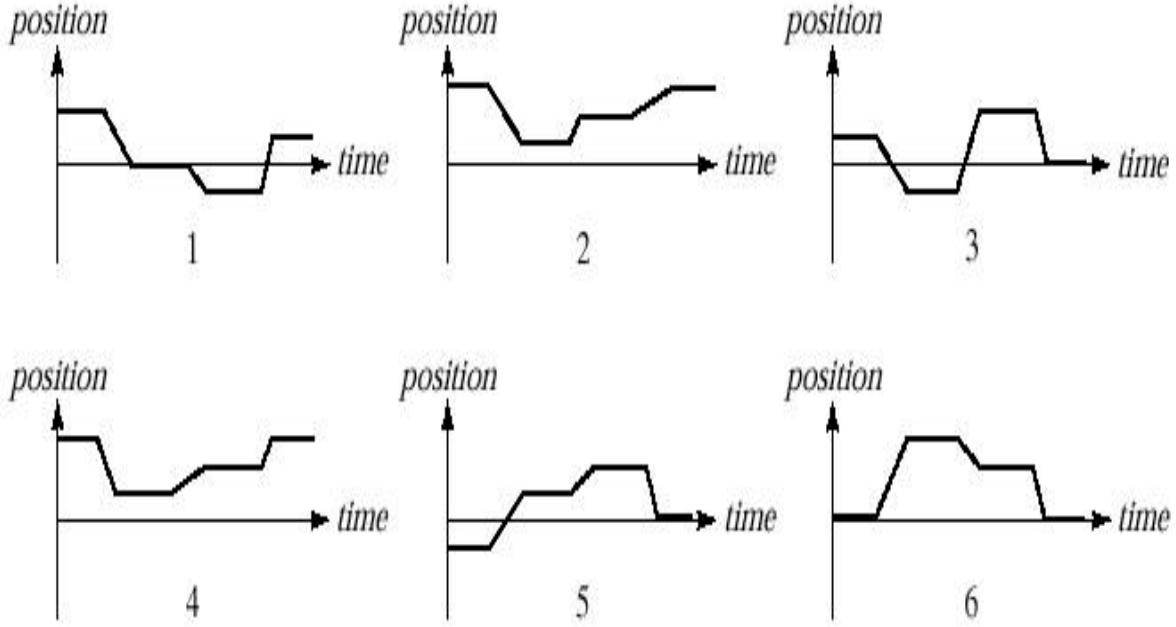


Problem 5.3



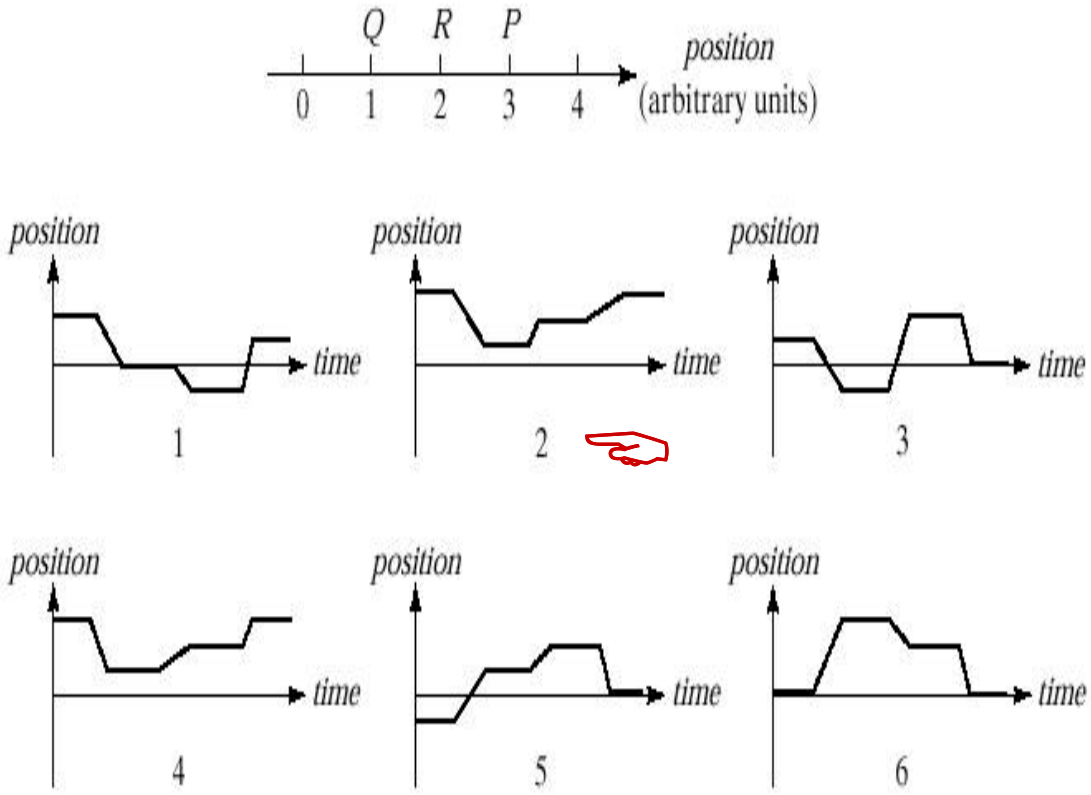
A person initially at point *P* stays there a moment, then moves along the axis to *Q* and stays there a moment. She then runs quickly to R, stays there a moment, and then strolls slowly back to P. Which of the position vs. time graphs below correctly represents her motion?





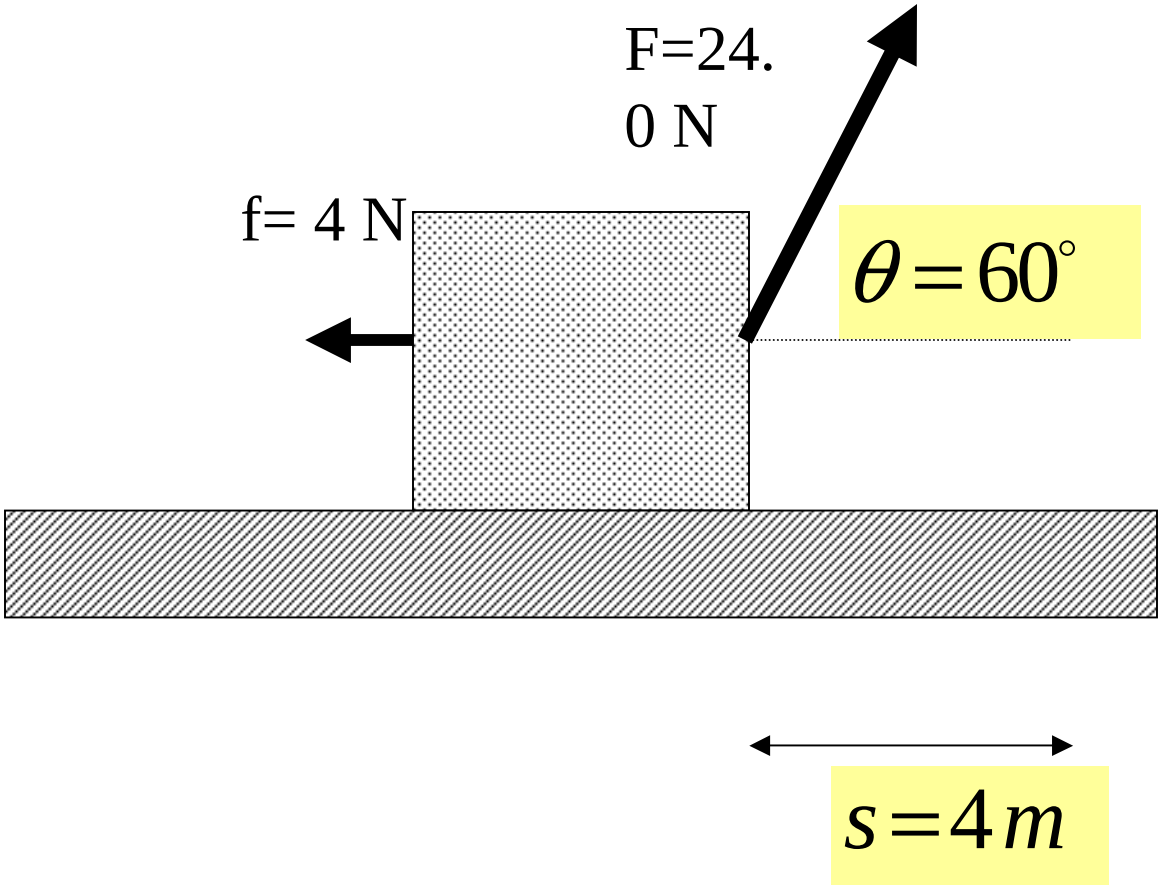
A person initially at point *P* in the illustration stays there a moment and then moves along the axis to *Q* and stays there a moment. She then runs quickly to R, stays there a moment, and then strolls slowly back to P. Which of the position vs. time graphs below correctly represents this

]



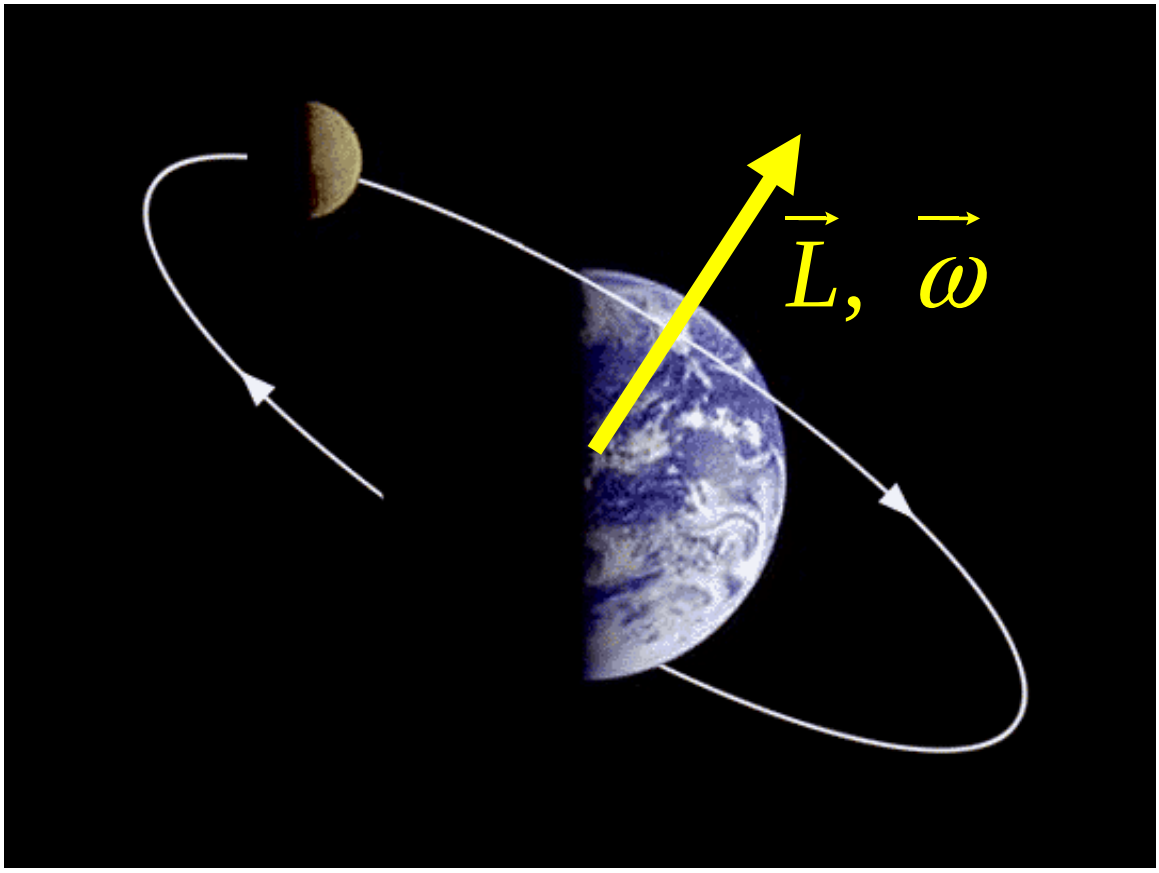
A box is dragged 4 m by a rope 60 degrees from horizontal.

The net work done on the box is?



a) 48 Watts b) 48 J c) 32 J d)16 J

The angular momentum $\vec{L}$ of the earth-moon system is conserved because:



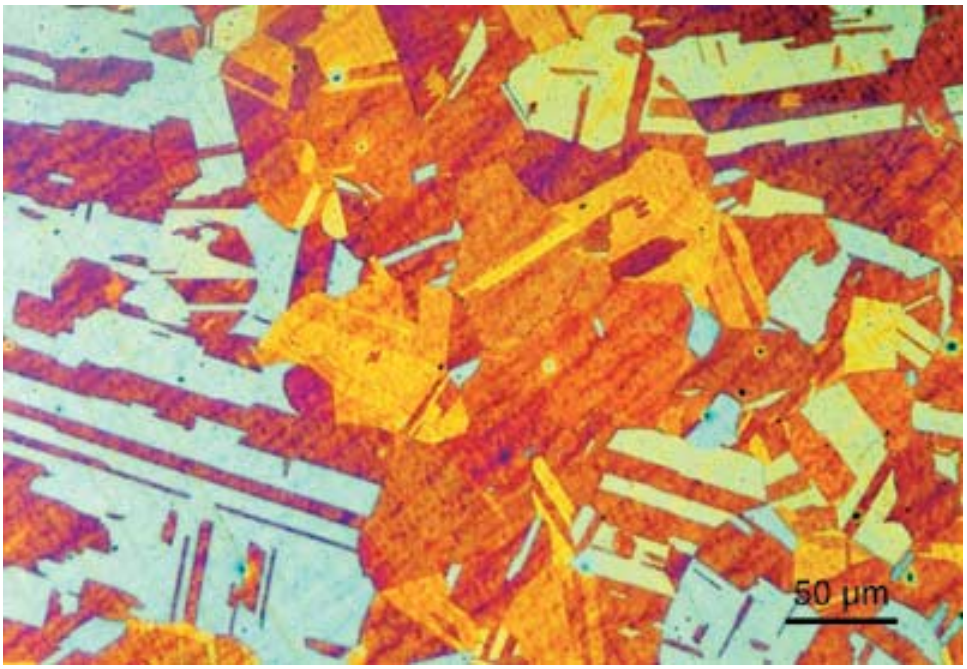
a) $\vec{L}$ Is <u>always</u> conserved

b) No external torques because $\vec{\tau}_{EM} = -\vec{\tau}_{ME}$

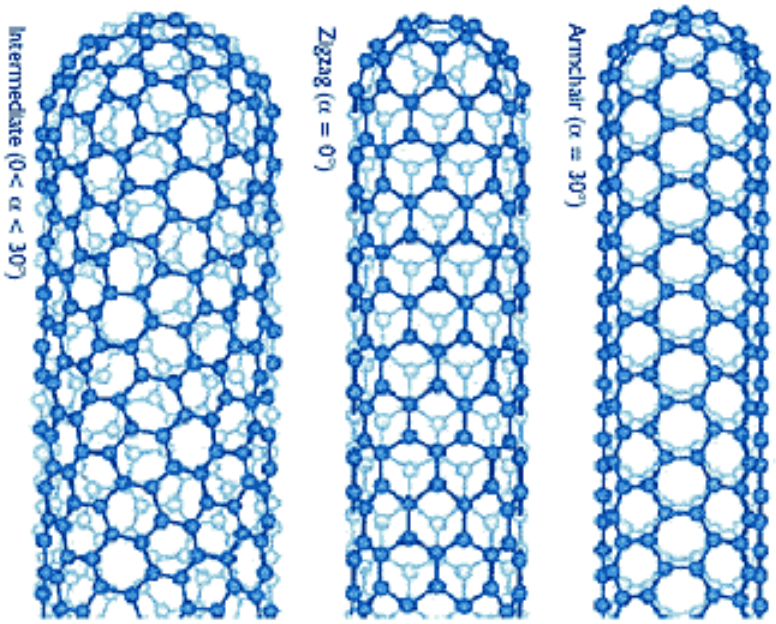
c) $\vec{L}$ <u>isn't</u> conserved, only $\vec{p}$ is.

d) Gravity can't exert a torque because it acts only along $\vec{r}$

Steel – Yield strength = 0.5 GPa



Carbon Nanotube – Yield strength = 10 GPa



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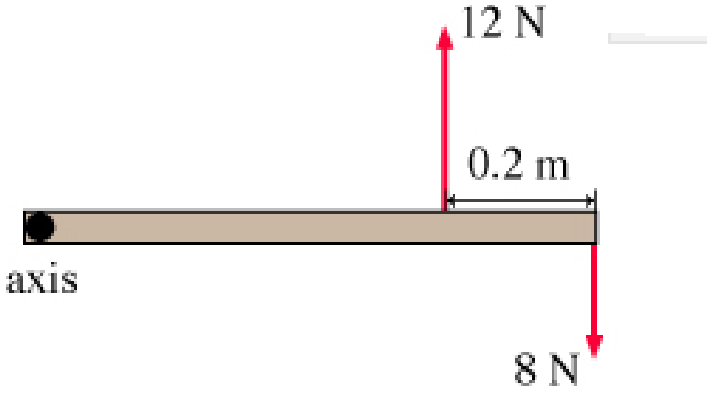
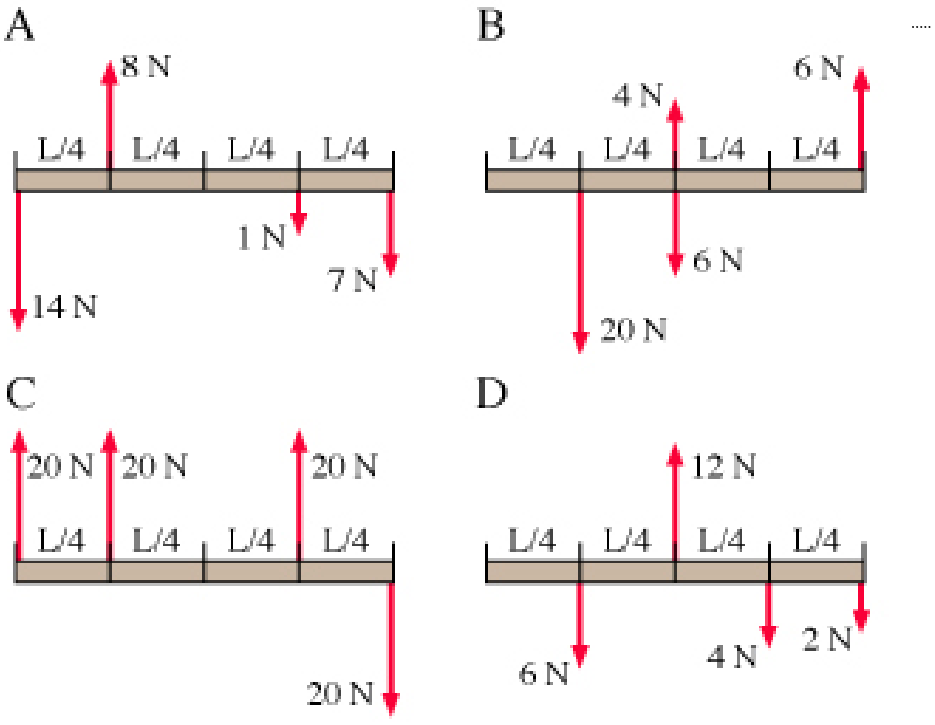
Simple Calculations with Torque



Calculate the torque about the left edge and about the center point of each of these systems



HEAT CAPACITIES OF GASES AND SOLIDS

Material	‘c’	M	‘C’
	J/kgK	kg/mol	J/moleK
Al	910	0.027	24.6
Cu	390	0.064	24.8
Fe	470	0.056	26.3
Pb	130	0.207	26.9
Ag	234	0.108	25.3
H2O	4190	0.018	75.4
He		0.004	12.47
Ar			12.47
H2		0.002	20.42
O2		0.032	21.1

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